Can Satellite Rainfall Help Us To Estimate Long-Term Flood Risks?

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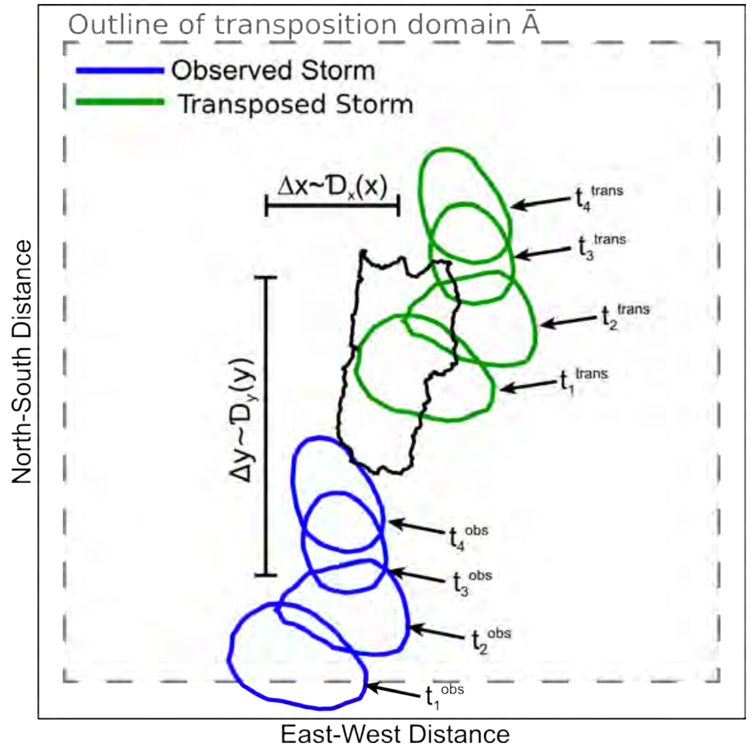
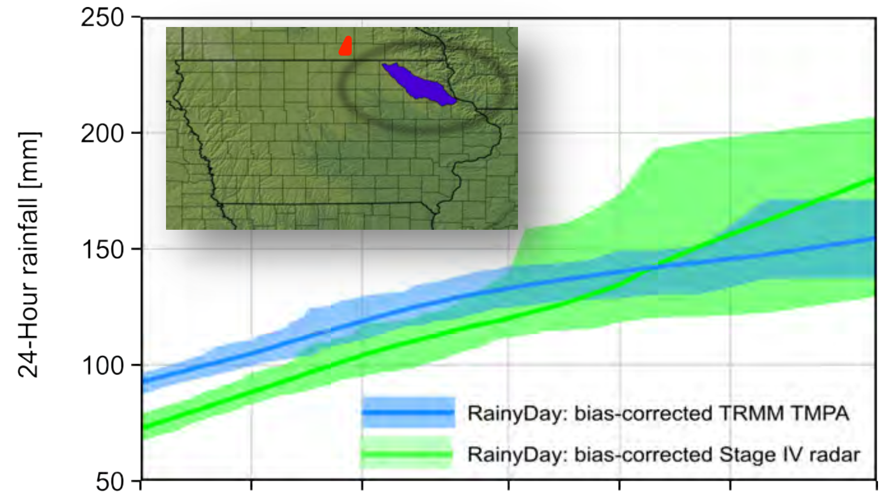
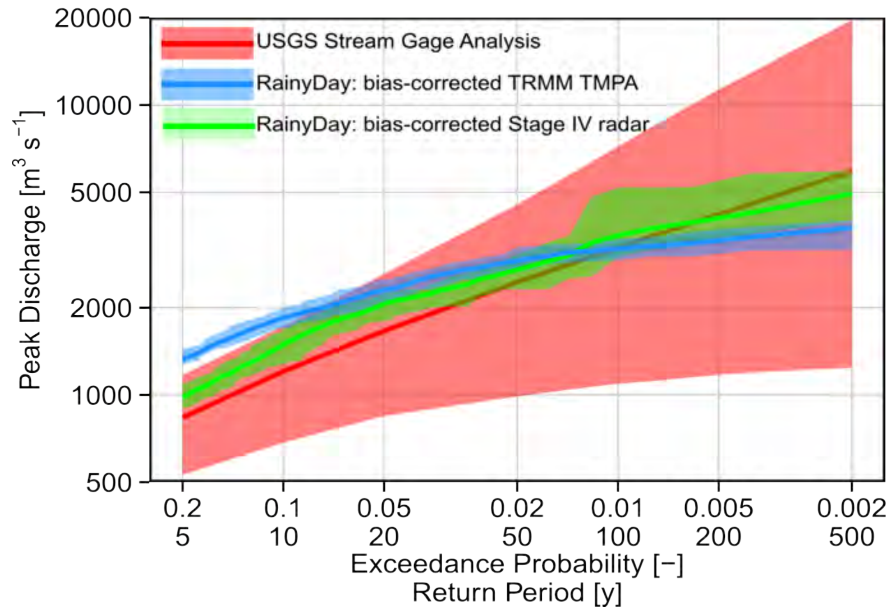


Using a regional stochastic storm transposition approach, satellite rainfall datasets such as TRMM TMPA and IMERG can be coupled with hydrologic models to estimate the probability and severity of extreme rainfall and floods anywhere on the globe and at multiple scales, even with short (10-15 year) remote sensing records. RainyDay is an open-source stochastic storm transposition tool developed at NASA/GSFC to facilitate such assessments.





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NASA POSTDOCTORAL PROGRAM
Administered by Oak Ridge Associated Universities

References:
Wright, D.B., R. Mantilla, C. Peters-Lidard, *RainyDay: A Remote Sensing-Driven Tool for Assessing Rainfall-Driven Hazards*, in prep.
Wright, D.B., J. A. Smith, G. Villarini, and M. L. Baeck, *Estimating the Frequency of Extreme Rainfall Using Weather Radar and Stochastic Storm Transposition*, J. Hydrology, 2013.
Wright, D.B., J.A. Smith, M.L. Baeck. *"Flood Frequency Analysis Using Radar Rainfall Fields and Stochastic Storm Transposition,"* Water Res. Research, 2014.

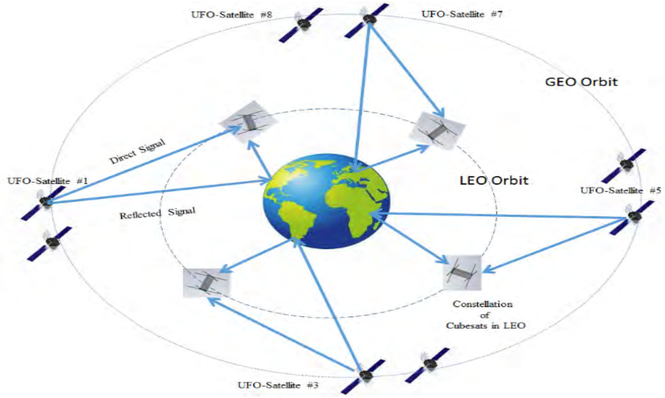
Data and Models:
RainyDay: Open-source stochastic storm transposition tool developed at NASA/GSFC to estimate long-term rainfall and flood hazards
NCEP Stage IV National Rainfall Product: 4 x 4 km spatial resolution, 60-minute temporal resolution with coverage over the continental United States, merging rainfall estimates from ground-based radar, rain gages, and (only in mountainous areas) satellite-based sensors
NASA TRMM TMPA Global Satellite Product: 0.25° x 0.25° spatial resolution, 3-hour temporal resolution with near-global coverage, merging satellite-based passive microwave and infrared imagery with monthly-scale rain gage-based bias correction
Iowa Flood Center (IFC) Iowa Flood Model: Multi-scale flood model using 2 soil layers resolved using the open-source ASYNCH tree-structure ODE solver library

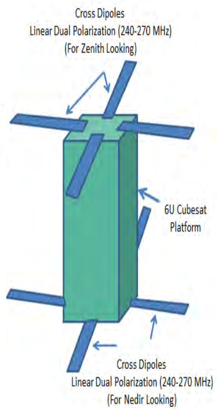
Technical Description of Figures:
Figure 1: Illustration of regional stochastic storm transposition concept. The dotted grey box outlines the transposition domain. A storm is selected at random from a remote sensing "catalog" of observed storms, and is geographically shifted according to the distributions $D_x(x)$,$D_y(y)$. For convenience, 4 ellipses illustrating rainfall at four time intervals (t_1, t_2, t_3, and t_4) are shown for the observed storm (blue) and transposed storm (green).
Figure 2: Rainfall and flood peak discharge estimates. Top: 24-hour rainfall intensity-duration-frequency relationships for the Turkey River watershed in northeastern Iowa generated using RainyDay with Stage IV and TRMM TMPA rainfall. Solid lines show ensemble means; shaded areas show the ensemble spread from 100 RainyDay runs. Bottom: Peak discharge estimates generated using RainyDay with Stage IV and TRMM TMPA rainfall datasets with the IFC Flood Model, compared with results from a extreme value analysis of observed flood peaks for the U.S. Geological Survey station at Garber, Iowa. Solid lines for RainyDay analyses show ensemble means, shaded areas show the ensemble spread from 10 runs of RainyDay. Solid lines for stream gage analysis show the expected value, shaded areas show the 90% confidence interval.

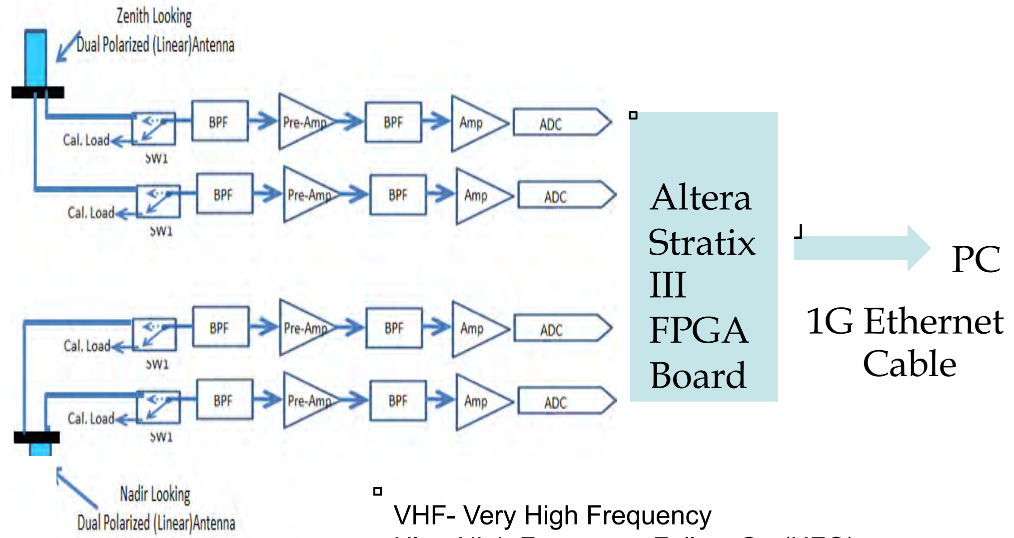
Scientific significance and societal relevance: Significant economic and social losses could be prevented through flood mitigation measures. Historically, however, our ability to quantify the probability and severity of extreme floods has been limited, especially in the developing world. This study demonstrates that existing archives of satellite-derived precipitation can be used within a regional stochastic storm transposition framework to quantify flood probability and severity at multiple scales anywhere on the globe. Accuracy will improve with the release of the full record of NASA's Integrated Multi-SatellitE Retrievals for GPM (IMERG), but is already comparable to that of stream gage-based flood peak estimates, which are subject to significant measurement and observational uncertainties and are available for only a tiny fraction of rivers globally. RainyDay is an open-source tool stochastic storm transposition tool developed at NASA/GSFC that, when coupled with high-resolution hydrologic and hydraulic models, facilitates the multi-scale estimation of potential flood impacts.

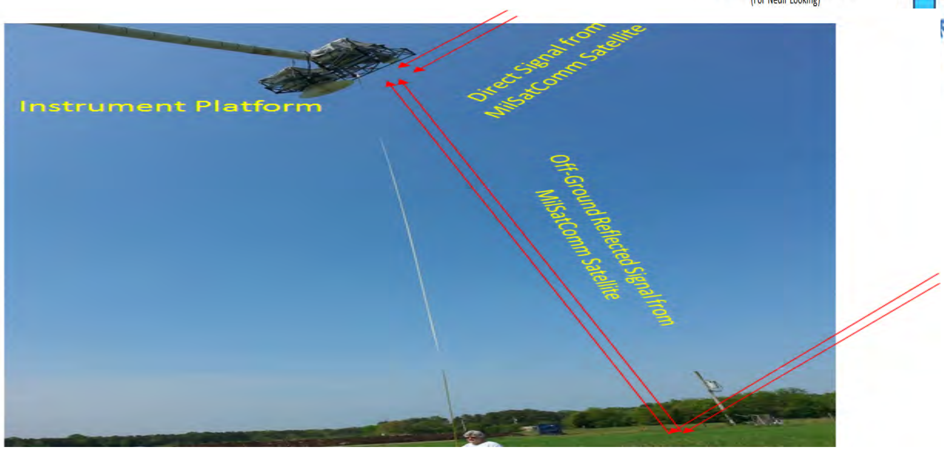
Design and Development of VHF (240-270 MHz) Antennas for SoOp (Signal of Opportunity) Receiver for 6U CubeSat Platforms

Alicia Joseph, Peggy O'Neill, Hydrological Sciences, NASA GSFC, Manohar Deshpande, Microwave Instrument Technology, NASA GSFC









VHF- Very High Frequency
Ultra High Frequency Follow-On (UFO)
BPF- Band Pass Filter
SW1 – Toggle Switch
ADC – Analog to Digital Convertor
LEO – Low Earth Orbit

Fabricated and tested VHF (Very Low Frequency, 250 MHz) antennas on a small 6U CubeSat platform.
Multiple VHF antennas (4) are used to receive direct as well as reflected signal. The mutual coupling is used to reduce interference of direct signal on the reflected channel
This project successfully used signal of opportunity techniques for remote sensing of soil moisture at longer wavelengths compared to the present L-band methods.

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Abstract: A four-channel VHF (Very High Frequency) (240-270 MHz) receiver hardware (compatible with 6U CubeSat platforms) was built by code 555 engineers and will be integrated with code 617's hydraulic boom truck. Successful operation of SoOp (Signal of Opportunity) receiver technology needs high isolation between direct and reflected channels. On a small platform (such as 6U CubeSat), achieving high isolation between the two closely spaced antennas becomes a challenging problem. Our technology approach is innovative in (1) providing the longer wavelength (1.2 meter wavelength, five times larger than existing instruments) observation capability needed to remotely sense RZSM (Root Zone Soil Moisture) through denser vegetation, and (2) achieving desired isolation of 18~20 dB between the direct and reflected channels and enhancement of gain by a factor of 2.

References:

SMAP L2_SM_P ATBD

Data Sources: Passive and active L-band microwave data from ComRad truck. Cubesat instrument mounted on ComRad truck.

Technical Description of Figures:

Figure 1: LEO (Lunar Exploration Orbiter) Mission Concept Using SoOp (Signal of Opportunity) Receivers. Figure 1 shows the CubeSat constellation concept for measuring soil moisture on a global scale.

Figure 2: VHF receiver block diagram for SoOp (Signal of Opportunity) remote sensing. Figure 2 shows the shows the basic hardware needed to be integrated with each CubeSat unit.

Figure 3: Figure 3 is showing a picture of ComRad microwave truck antenna platform identifying placement of CubeSat integration.

Scientific significance:

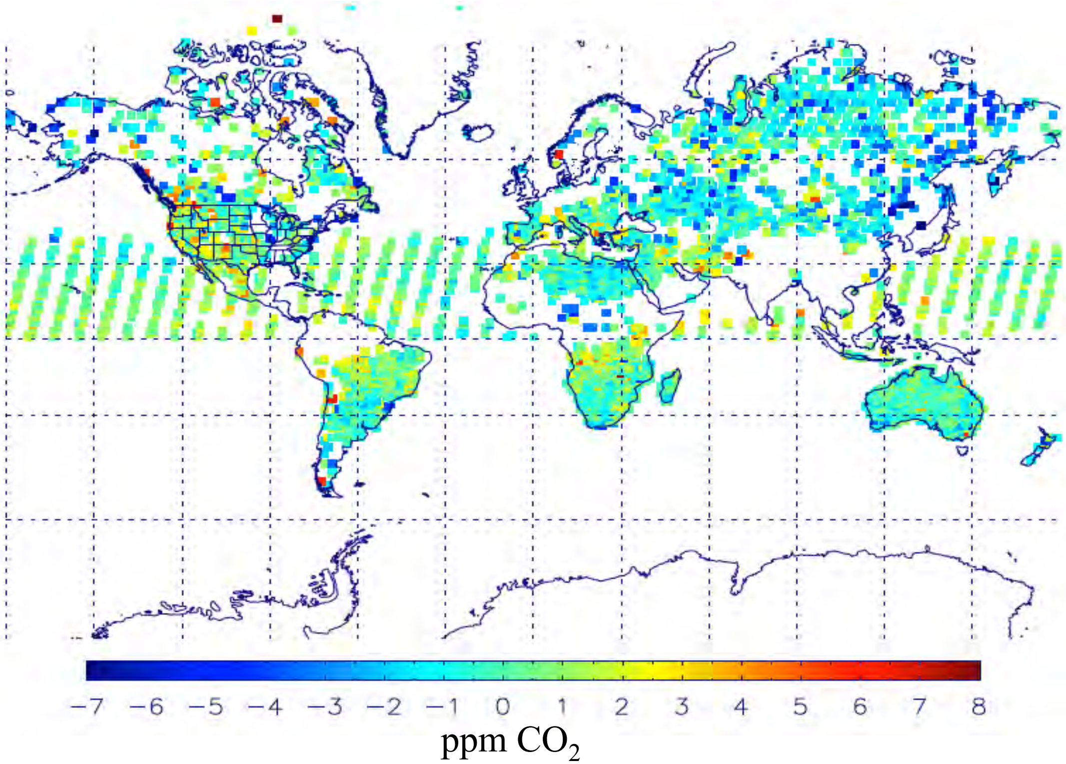
Developing bi-static reflectometry using VHF (250 MHz) geostationary satellite signals of opportunity creates the potential for observing root zone soil moisture on a global basis from a constellation of small satellite-based receivers in low Earth orbit. The technique provides the long- wavelength observations needed to remotely sense RZSM (at least to a deeper layer than current L band approaches and through denser vegetation). At the same time, it overcomes spectrum management restrictions because our instruments are passive (receive only).

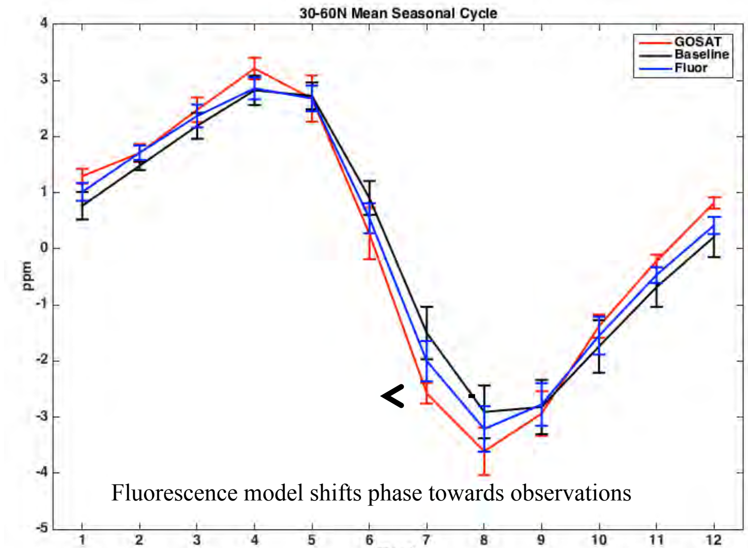
Relevance for future science and relationship to Decadal Survey:

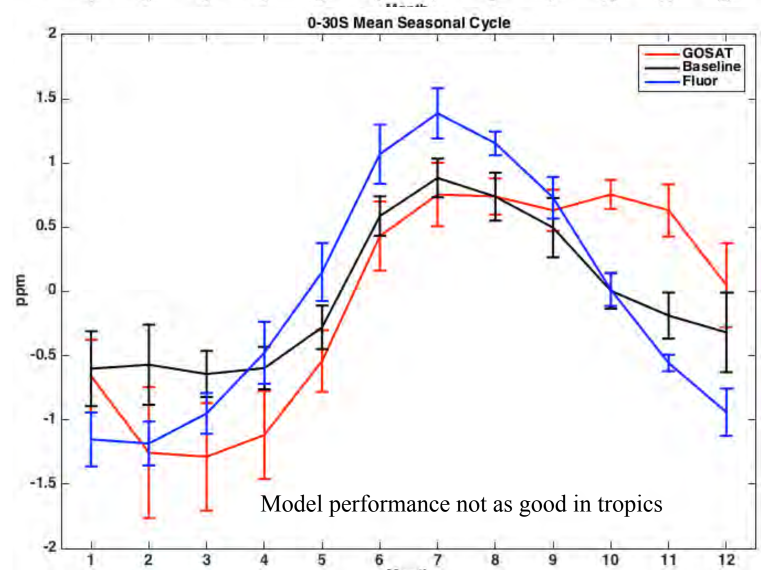
GSFC is involved in number of CubeSat flight projects. Receiving multiple new GPS signals enables Precise Orbit Determination (POD). POD enables more accurate high resolution gravity field mapping of planetary bodies. New L2C signals are high strength signals capable of penetrating heavy foliage (good for soil moisture using SoOp technology). In recent years there has been increasing interest in SoOp technology for spaceborne applications. Successful demonstration of SoOp receiver technology for 6U Cubesat platforms will further mature this technology (e.g. TRL 6).

First demonstration of the use of satellite fluorescence in a carbon cycle model and evaluation using space based measurements of atmospheric CO_2

G. James Collatz, Biospheric Sciences NASA GSFC, Joanna Joiner and Stephan R. Kawa, Atmospheric Chemistry and Dynamics, NASA GSFC







New satellite based measurements of atmospheric CO_2 and chlorophyll fluorescence provide new and potentially powerful tools for solving the mystery of the land carbon sink.

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References:

Collatz, G.J., Joiner, J., Kawa, S.R., Ivanoff, A., Liu, Y., Yoshida, Y., Zeng, F. 2015: Using satellite fluorescence data to drive a global carbon cycle model: Impacts on atmospheric CO2. (*in prep.*)
Joiner, J., et. al. 2014: The seasonal cycle of satellite chlorophyll fluorescence observations and its relationship to vegetation phenology and ecosystem atmosphere carbon exchange, *Remote Sensing of Environment*, 152, 375–391, dx.doi.org/10.1016/j.rse.2014.06.022

Data Sources: NASA products: GIMMS3g NDVI, GFED Fire Emissions (based on MODIS derive burned area), MERRA meteorology and atmospheric transport, GOME-2 fluorescence, ACOS CO2 from GOSAT. Other: Takahashi Ocean fluxes, CDIAC fossil fuel emissions

Technical Description of Figures:

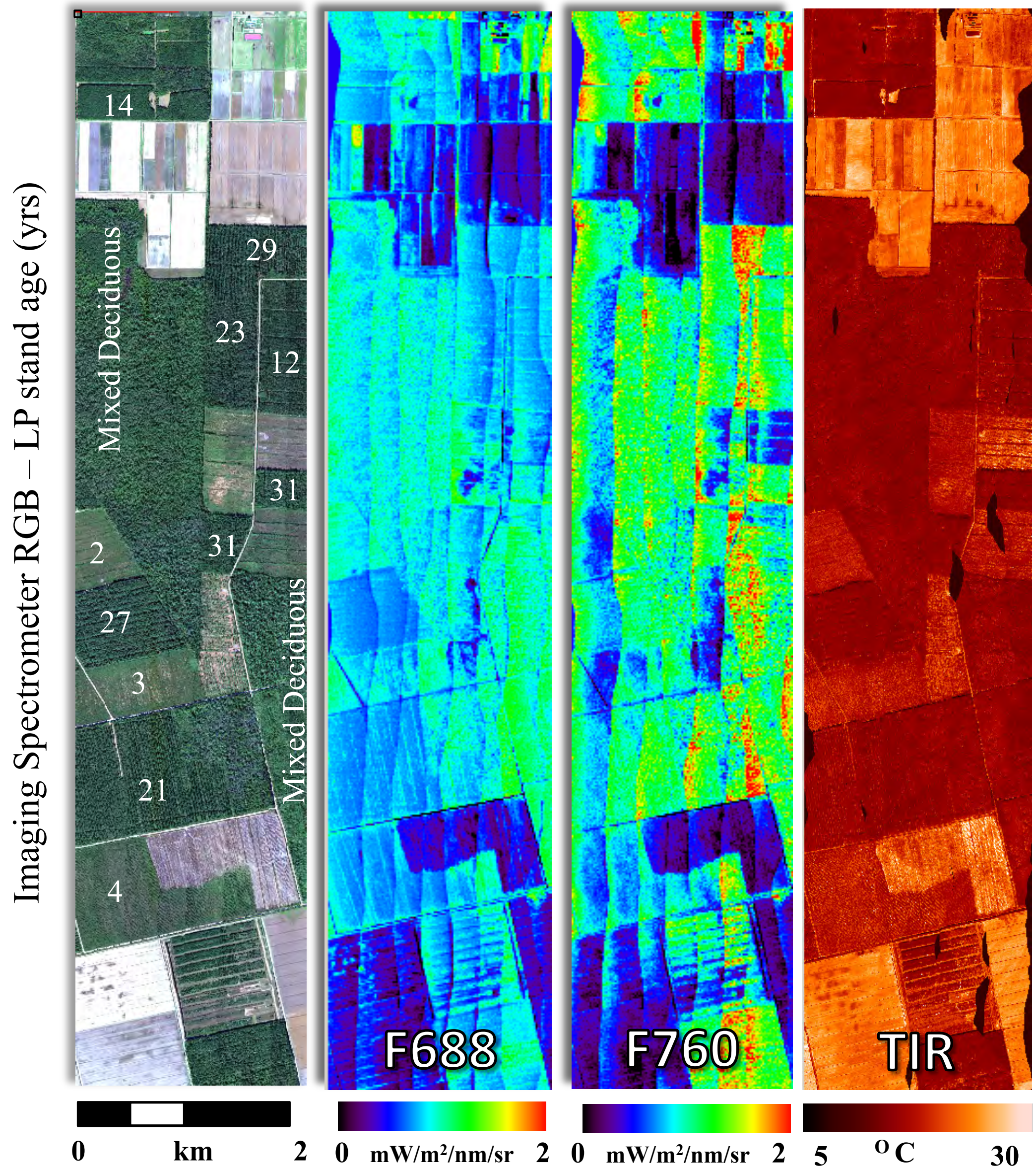
Graph a) *:*
Map of the difference between Baseline Model and GOSAT ACOS monthly average column CO_2 for July 2010. The GSFC Parameterized Chemistry and Transport Model (PCTM, based on MERRA/GEOS-5) was used to transport CO2 produced by Land vegetation (NASA CMS Land Carbon Flux product), ocean, and fossil fuel carbon fluxes. The modeled column CO_2 distributions were then sampled at the spatial and temporal resolutions of the GOSAT ACOS data.
Graph b) The mean seasonal cycle in atmospheric column CO_2 variability measured by GOSAT ACOS (Red) averaged over 30N-60N latitude band and modeled using the NDVI driven CMS Land Carbon Flux product (Black), and the modified model incorporating GOME2 fluorescence data. The error bars represent the standard deviation in measurements and models for the 4 ½ year period of observations. Both models capture the seasonal cycle and variability well but the fluorescence driven model matches the seasonal cycle phase better than the baseline model. This is because the fluorescence model predicts earlier onset of carbon uptake by the vegetation.
Graph c) Similar to Graph b) except for 0-30S latitude band. Both models produce phase differences and greater amplitudes than observations. Tropical land fluxes are problematic from both modeling and observational perspectives. Limited satellite coverage in the tropics due to cloud interference reduces the effectiveness CO_2, vegetation greenness, and fluorescence measurements for constraining flux prediction. Better CO_2 and fluorescence measurements are expected in the future and are needed to understand the impacts of tropical land fluxes on the atmospheric CO_2 budget.

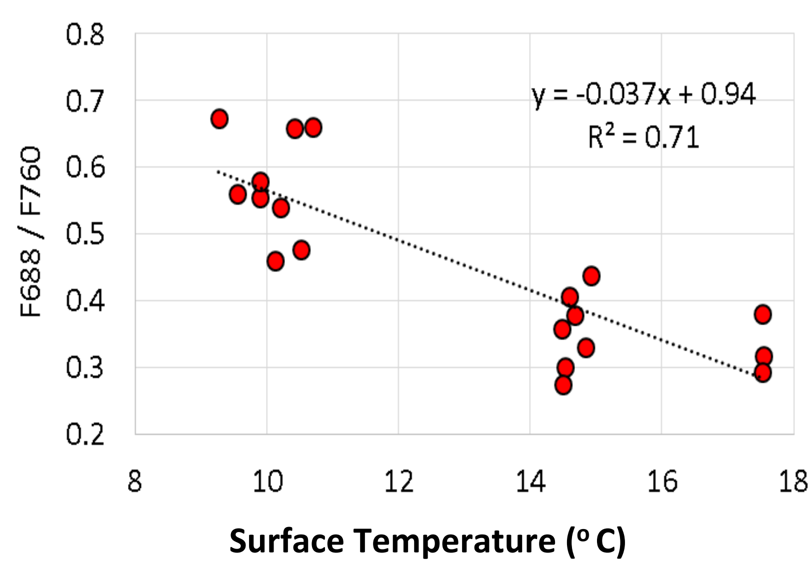
Scientific significance, societal relevance, and relationships to future missions: From atmospheric measurements (e.g. Mona Loa) we know that on average around ¼ of the CO_2 emitted globally each year by humans is taken up by land vegetation amounting to nearly 100ppm less atmospheric CO_2 since the industrial revolution (current levels are ~400ppm). However, the locations and mechanisms are as yet unresolved and uncertainty in the future behavior may be as large as it is for future fossil fuel emissions. Will the land biosphere continue to mitigate greenhouse gas driven climate change or in the other extreme release greater amounts of CO_2 into the atmosphere further exacerbating climate change? This question has focused attention on developing capabilities to measure atmospheric CO_2 more precisely in time and space and on improving estimates of biospheric carbon exchanges. To date the most precise estimates of land carbon fluxes use satellite greenness indicies (e.g. NDVI) to derive the amount of sunlight absorbed for photosynthesis. This approach is likely to be biased because not all sunlight absorbed by vegetation is used for photosynthesis. Chlorophyll fluorescence from leaves provides a direct signal of photosynthetic activity integrating absorbed sunlight and physiological function. Recently it has been possible to extract chlorophyll fluorescence signals from satellite instruments that were not designed for that purpose (GOSAT, GOME-2, OCO-2) providing global data of photosynthetic activity. Here we use vegetation greenness versus fluorescence to drive modeled atmospheric CO_2 variability and compare with satellite based CO_2 observations. We find that fluorescence driven model can do as well or better than the state-of-the-art NDVI driven model. However, some regions such as the tropics remain poorly resolved by both models and further improvements in characterization of the vegetation and atmospheric CO_2 variability are necessary.

OCO-2 promises to provide improved atmospheric CO_2 and vegetation fluorescence measurements. Currently proposals for potential future missions designed specifically to measure chlorophyll fluorescence are under consideration by NASA and ESA.

Unique Fluorescence & Thermal Imagery Reveal Photosynthetic Function

Elizabeth Middleton, Biospheric Sciences, NASA GSFC and Corp, Cook and Rascher, Forschungszentrum Jülich, Germany





Novel combination of airborne thermal (TIR) and fluorescence (F) images relate plant function to energy balance and the carbon cycle.

Both red (F688) and far-red (F760) fluorescence contribute to capturing plant responses. Their ratio expresses photosynthetic efficiency, which decreases with increasing temperature.

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References:

Corp, L.A., B. Cook, F. Pinto, E. Middleton, K. Huemmrich, P. Campbell, U. Rascher, and A. Noormets (2015). Airborne remote sensing to define ecosystem form and function over a loblolly pine plantation. Proceedings, 2015 IEEE International Geoscience and Remote Sensing symposium (IGARSS) 2015, Milan, Italy, July 26-31, 4pp.

Middleton, E.M., Y.-B. Cheng, P.K.E. Campbell, L.A. Corp, Q. Zhang, K.F. Huemmrich, D.R. Landis, W.P. Kustas, A.L. Russ, 2014. Daily light use efficiency in a cornfield can be related to the canopy Red/Far-Red fluorescence ratio and leaf light use efficiency across a growing season. Proceedings, 5th Workshop on Remote Sensing of Vegetation Fluorescence, Paris, France, April 2014, 9 pp.

Moreno, J., Y. Goulas, A. Huth, E. Middleton, F. Miglietta, G. Mohammed, L. Nedbal, U. Rascher, W. Verhoef. (2015). Report for mission selection: FLEX. An Earth Explorer to observe vegetation fluorescence. Fletcher, K. (Editor). European Space Agency. Noordwijk, the Netherlands. 197 pp.

Data Sources: NASA Goddard's LiDAR Hyperspectral Thermal Airborne Imager open access data products available at: gliht.gsfc.nasa.gov. HyPlant data products from Forschungszentrum Jülich, Germany. HyPlant is the prototype instrument for the FLEX mission.

Technical Description of Figures:

Graphic 1 (left): Airborne imagery were collected in the FLEX-US Campaign in October 2013 over the Parker Tract loblolly pine plantation in North Carolina. The four strips show (from left to right): the red-green-blue reflectance composite from the HyPlant Dual spectrometer; the red and far-red fluorescence retrieved from the HyPlant IBIS spectrometer; and the thermal data from G-LiHT. The original 2 m pixels are aggregated to 14 m to match the LiDAR data (not shown).

Graphic 2 (right): The relationship of the red/far-red fluorescence ratio (F688/F760) is plotted vs. the retrieved surface temperature. A significant relationship was observed between SIF and surface temperature.

Scientific significance, societal relevance, and relationships to future missions:

Fluorescence observed from remote sensing platforms directly responds to vegetation physiological function. We demonstrate that fluorescence, especially both critical retrievals in the red and far-red spectrum, can be retrieved at high spatial resolution (~14 m) from aircraft. The FLEX-US campaign collected a unique combination of LiDAR, hyperspectral reflectance, fluorescence, and surface temperature imagery. Several atmospheric chemistry satellites provide far-red fluorescence at a coarse spatial scale. The FLEX-US campaign tested new technologies and methods for cal/val of FLEX mission products. Currently, missions optimized for retrieval of both the red and far-red fluorescence are under development. Our data show the benefit of combining thermal information with fluorescence to estimate photosynthetic efficiency in response to environmental conditions, a capability that will be possible with the FLuorescence EXplorer (FLEX) mission and from the ISS when both ECOSTRESS and OCO-3 are deployed. This research is leading to improved measurement and modeling of plant productivity and responses.

Climate Data Initiative Releases Arctic Data and Tools

Curt Tilmes, Terrestrial Information Systems, NASA GSFC

Figure 1

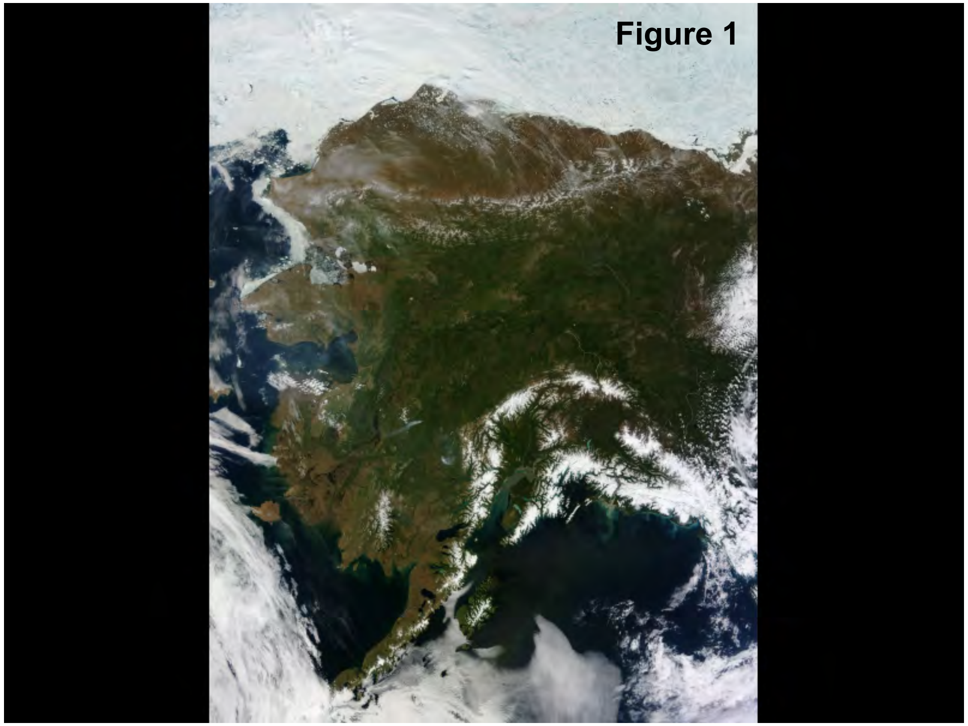

Figure 2

The White House
Office of the Press Secretary
For Immediate Release

September 02, 2015

FACT SHEET: President Obama Announces New Investments to Combat Climate Change and Assist Remote Alaskan Communities

On September 2nd, the White House announced Climate Data Initiative release of 250 Arctic-related datasets (32 of which are being made available for the first time), and more than 40 maps, tools, and other resources in support of the Arctic theme.

The new theme supports climate-resilience efforts in Alaska and the Arctic, including 10 "Taking Action" case studies in key areas of climate-change risks and vulnerability for Alaska and the Arctic.

Name: Curt Tilmes, Terrestrial Information, NASA GSFC
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References:
FACT SHEET: Administration Announces Actions To Protect Communities From The Impacts Of Climate Change. https://www.whitehouse.gov/the-press-office/2015/09/02/fact-sheet-president-obama-announces-new-investments-combat-climate

National Climate Assessment. http://nca2014.globalchange.gov/

FACT SHEET: The President's Climate Data Initiative: Empowering America's Communities to Prepare for the Effects of Climate Change. https://www.whitehouse.gov/the-press-office/2014/03/19/fact-sheet-president-s-climate-data-initiative-empowering-america-s-comm

Data Sources:
Climate Data Initiative: http://www.data.gov/climate/
ArcticTheme: http://www.data.gov/climate/arctic/

Technical Description of Image:
Figure 1: On most days, relentless rivers of clouds wash over Alaska, obscuring most of the state's 6,640 miles (10,690 kilometers) of coastline and 586,000 square miles (1,518,000 square kilometers) of land. The south coast of Alaska even has the dubious distinction of being the cloudiest region of the United States, with some locations averaging more than 340 cloudy days per year. That was certainly not the case on June 17, 2013, the date that the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite acquired this rare, nearly cloud-free view of the state. The same ridge of high pressure that cleared Alaska's skies also brought stifling temperatures to many areas accustomed to chilly June days. Talkeetna, a town about 100 miles north of Anchorage, saw temperatures reach 96°F (36°C) on June 17. Other towns in southern Alaska set all-time record highs, including Cordova, Valez, and Seward. The high temperatures also helped fuel wildfires and hastened the breakup of sea ice in the Chukchi Sea. (Figure source: Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on the Terra satellite, Land Rapid Response Team, NASA/GSFC) http://www.nasa.gov/multimedia/imagegallery/image_feature_2534.html#.Vehbq4uxHeM

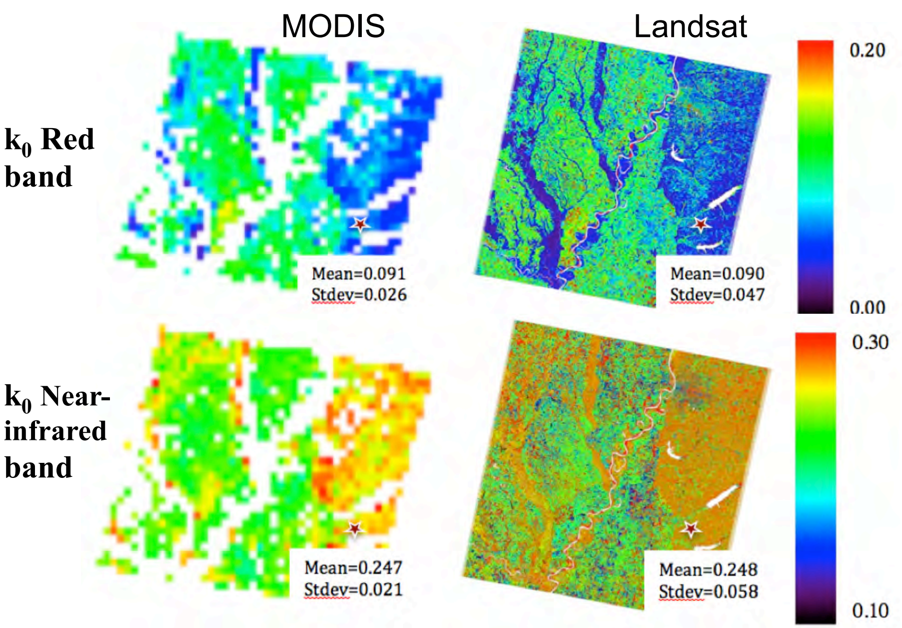
Figure 2: FACT SHEET: President Obama Announces New Investments to Combat Climate Change and Assist Remote Alaskan Communities https://www.whitehouse.gov/the-press-office/2015/09/02/fact-sheet-president-obama-announces-new-investments-combat-climate

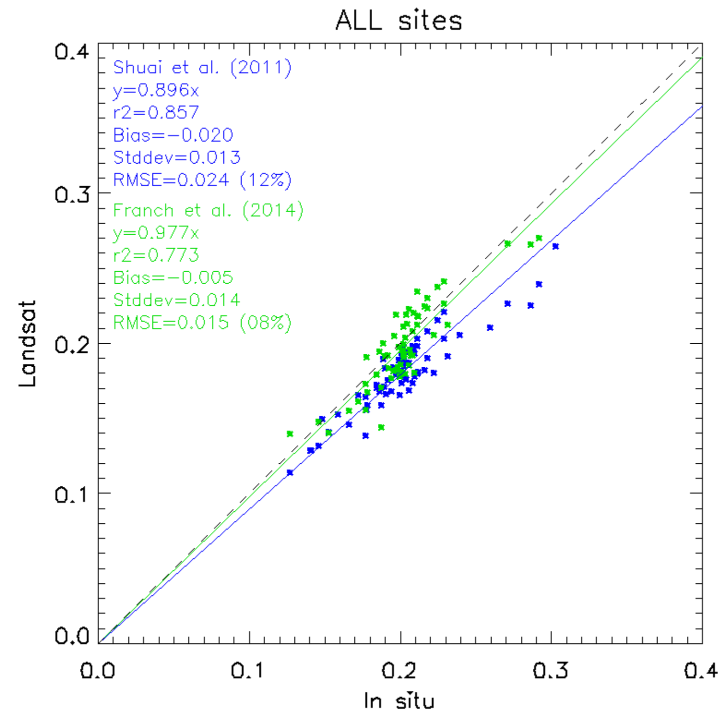
Scientific significance: NASA is helping the Federal Government identify data and resources relevant to building climate resilience, and making those more discoverable, accessible and usable by the Data Innovation Community. NASA was tasked with implementing the White House Climate Data Initiative (CDI), and is working closely with the EOP and other Federal Agencies to make available relevant data and resources within the Federal Government to support climate resilience. These resources, available at climate.data.gov, are organized around eight different themes: 1) Coastal Flooding, 2) Food Resilience, 3) Water, 4) Ecosystem Vulnerability, 5) Human Health, 6) Energy, 7) Transportation, and 8) Arctic.

Relevance for future science and relationship to Decadal Survey: The CDI exercise helps NASA, and the Federal Government in general, identify the most relevant data for applied sciences, and assess any existing gaps in Earth Observation data, knowledge and information.

Inter-comparison of Landsat albedo retrieval techniques and evaluation against in situ measurements across the US SURFRAD network.

Belen Franch, Terrestrial Information Systems, NASA GSFC, UMD





This analysis presents an algorithm to derive a Landsat surface albedo based on the BRDF parameters estimated from the MODerate resolution Imaging Spectroradiometer (MODIS) Climate Modeling Grid (CMG) surface reflectance product using the method described in Vermote et al., 2009.

The results show that the proposed method derives the surface albedo with a Root Mean Square Error (RMSE) of 0.015 (7%). This is a substantial improvement in the RMSE compared to Shuai et al. (2011) method (with a RMSE of 0.024, 12%). The albedo is critical for accurate evapotranspiration estimates and is a fundamental input for climate models.

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Phone: (301) 614-5846

References:

Franch, B., Vermote, E. & Claverie M. (2014). Intercomparison of Landsat albedo retrieval techniques and evaluation against in situ measurements across the US SURFRAD network. Remote Sens. Environ., vol. 152, pp. 627-637

Shuai, Y., Masek, J., Gao, F. & Schaaf, C. B. (2011). An algorithm for the retrieval of 30-m snow-free albedo from Landsat surface reflectance and MODIS BRDF. Remote Sens. Environ., vol. 115, no. 9, pp. 2204–2216.

Vermote, E., Justice, C. O., & Bréon, F. M. (2009). Towards a generalized approach for correction of the BRDF effect in MODIS directional reflectances, *IEEE Transactions on Geoscience and Remote Sensing*, *47*(3), 898-908.

Data Sources: The MODIS and Landsat surface reflectance were developed by Code 619 and the MODIS surface reflectance product is generated by Code 619.

Technical Description of Figures:

Figure 1: k0 images in the red band (top) and the near infrared band (bottom) in Goodwin Creek, MS, on September 30th of 2005. The images on the left correspond to MODIS CMG BRDF parameters at 0.05° spatial resolution (5600 m) while images on the right correspond to Landsat spatial resolution (30 m) as result of the disaggregation. The mean and standard deviation showed in each image represent the global statistics of the whole scene. The red star points out the location of the SURFRAD station.

Figure 2: Validation of the proposed algorithm and Shuai et al. (2011) Landsat albedo products with in situ data retrieved from SURFRAD stations from 2003 to 2006 and using Bondville and Table Mountain results with the albedo derived from the improved atmospheric correction. We tested the proposed algorithm over five different sites of the US Surface Radiation (SURFRAD) network and inter-compare our results with Shuai et al. (2011) method.

Scientific significance:

Continuous and systematic high quality Earth Observations from NASA satellites provide the critical synoptic and objective information needed by applications of societal benefit in the context of growing population and climate change.

Relevance for future science and relationship to Decadal Survey:

Demonstrating how to use current sensors to understand our changing planet and delivering those data to the global community is part of NASA mission and is critical to develop future missions and sensors to further improve other government agencies and partner organizations decision-making.